Docket No. SA-537

Exhibit No. 6-H

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

Attachment 7 – Test Plan and Results of Tensile Testing

(22 Pages)

AIR CRUISERS
AEROSAFETY & TECHNOLOGY
Emergency Evacuation Systems

ZODIAC AEROSPACE

ENGINEERING DOCUMENT NUMBER 4105

777 Pack Release Mechanism Strength Test Plan

Forced Failure via Tensile Pull

REVISION C
(See Page 2 for Revision Control Sheet)

Prepared by: [redacted]
Robert Hentges
Boeing Program Manager
Air Cruisers' Party Coordinator for DCA13MA120

Distribution: NTSB, FAA, Boeing, Asiana, EVV, MKT, PLA

Q:\EDN\EDN-4105.doc

Revision Control Sheet

REV.	DATE	DESCRIPTION	APPROVAL
A	20 August 2013	Initial Issue	RHE
B	10 September 2013	Incorporated Boeing Comments • Reformatted sections 8.1 & 8.2 to include testing in the Download direction. • Added testing in the Inboard direction with pin shields removed. • Converted testing with modified pin shield from Inboard loading to Downward loading. • Added Figures 6 & 7 • Added test quantities to Para 6.0.	RHE
C	30 October 2013	Incorporated NSTB Comment • Revised sections 8.1.1 & 8.1.2 to include a third mounting bolt. • Revised Figure 5 to show all three bolts.	[redacted]

1.0 PURPOSE

The purpose of this EDN is to document the test plan to be followed in conducting tensile tests on 777 packboard release mechanisms at Air Cruisers' facility.

2.0 BACKGROUND INFORMATION

On July 6, 2013, a Boeing 777-200ER operated by Asiana Airlines as flight 214 crashed in San Francisco, California. NTSB investigation held at the site of the crash revealed that two of the escape slides (DR1 right & DR 2 right) deployed inside the cabin. The subject systems were sent to Air Cruisers facility in Wall, NJ for further investigation. In addition to DR1 & DR2 right, the following other items were also sent to NJ for investigation: DR3L, DR4R, DR3R (packboard only), DR4L (packboard & girt bar only).

The investigation revealed a failure mode of the pack release mechanism. The release shafts showed signs of damage in the interface area of the tang. Minor cases showed bulging of the aluminum shaft while more severe cases showed a fracture of the aluminum and significant displacement of the tang. See Figure 1.

Figure 1. Damage to Release Shaft Door 2 RH.

3.0 APPLICABLE DOCUMENTS

NTSB Survival Factors Group Field Notes – July 16, 2013

NTSB Survival Factors Group Field Notes – July 31, 2013

68766 – 777 Packboard Release Assembly drawing

62678 – Release cable drawing

SK10414 – Release Cable Block drawing

SK10415 – Mounting Support drawing

62751 – Girt Cable (Pack Release Pill)

4.0 TEST GOALS

The purpose of the testing detailed in this plan is to understand the level of force that needs to be applied to the release mechanism to cause the lower lacing cover to release from the mechanism. An additional goal is to replicate the same type of damage seen on the escape slides from the Asiana Flight 214 aircraft.

5.0 TEST LIMITATIONS

It is understood that the actual direction, duration, and frequency of loads that the escape slides experienced on flight 214 cannot be known with any degree of certainty. The testing described in this plan does not purport to recreate the crash loads. The tensile testing described herein will only provide information on the failure mode and force levels required to separate the lower lacing cover from the release mechanism when pulled at the maximum rate possible utilizing the existing Baldwin tensile test machine at Air Cruisers' facility.

6.0 TEST SETUP

It is planned to test a total of six release assemblies. Two will benchmark an inboard load. Two will benchmark a downward load. One will test the inboard load with the pin shields removed. One will test the downward load with the pin shield fastening modified as described in Para

8.2.2. All tests will use a common packboard tray trimmed piece as well as the Release Cable Block and Mounting Support. New Release Cables will be utilized for each test.

The equipment utilized for these tests will consist of a Baldwin tensile test machine. See Figure 2. As the machine has only an analog dial gage, a calibrated 5000 pound S-beam load cell will be placed in-line with the tensile load to enable continuous force recording with data acquisition software.

Figure 2. Baldwin Tensile Machine.

A section of a 777 packboard that contains the release mechanism will be trimmed such that it will fit into the test setup. See Figure 3.

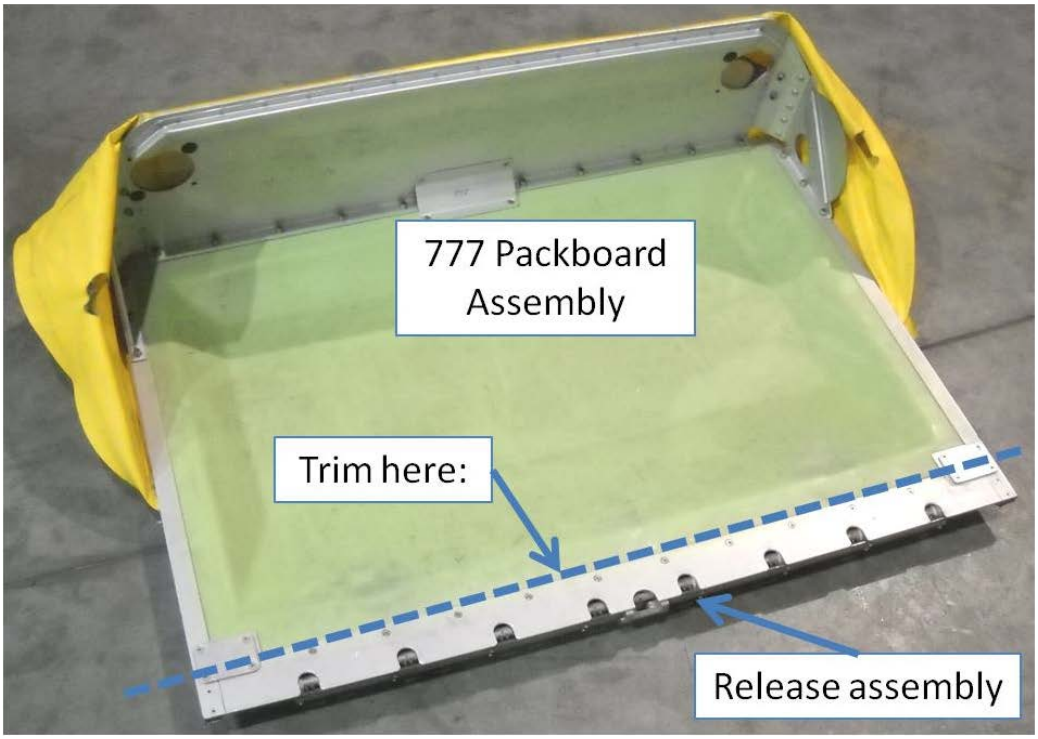


Figure 3. Packboard Trim Location

The trimmed packboard including the release mechanism will be fastened to the base of the tensile machine. Eight release cables will be inserted through the Release Cable Block, and then engaged with the roll pins on the release shaft which is representative of the release cable engagements on actual slide packs. The bottom end of a 5000 pound S-beam load cell will be attached to the Release Cable Block while the top of the load cell will be connected to the moveable top of the tensile machine. See Figures 4 & 5 for computer models of the proposed test setup.

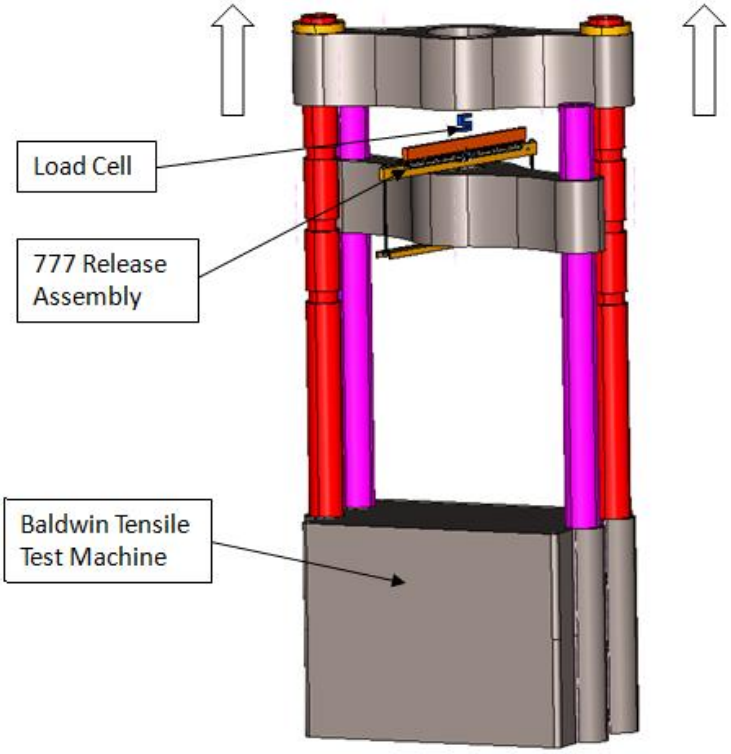


Figure 4. Overall model of test setup

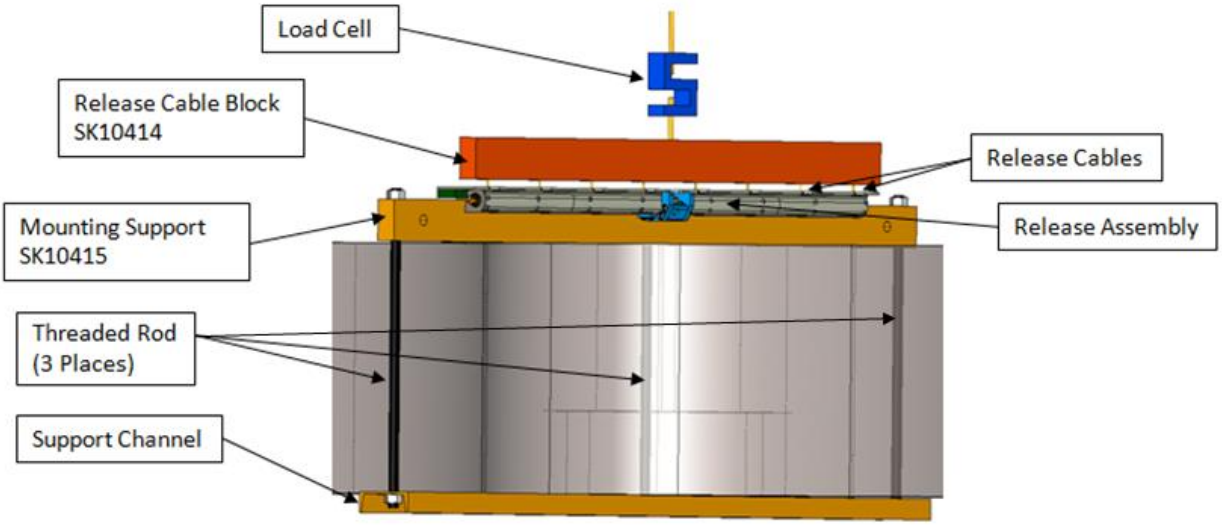


Figure 5. Zoomed in model view of test setup

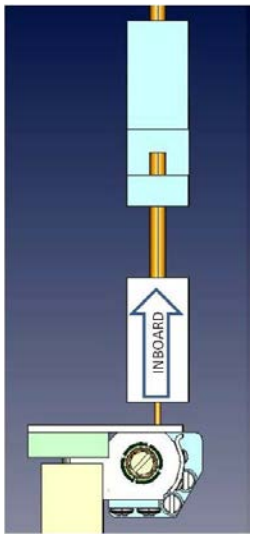


Figure 6. Inboard load direction

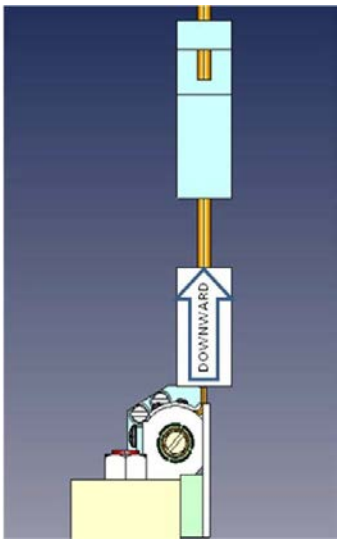


Figure 7. Downward load direction

7.0 VIDEO COVERAGE

At least two high-definition video cameras will be placed on each side of the tensile machine to record the tests. These cameras utilize industry standard frame rate of 30fps. In addition to those cameras, a high speed camera utilizing a frame rate of 300fps will be placed to record the release shaft throughout the test.

8.0 TEST PROCEDURE

8.1 BASELINE TESTING

The purpose of baseline testing is to obtain data showing the force required to cause failure to a properly assembled release mechanism.

8.1.1 INBOARD LOAD

1. Mount a new release assembly (68766-101) onto the trimmed packboard section.
2. Fasten the trimmed packboard section to the Mounting Support (SK10415) using ten #8 fasteners as shown in Figure 6.

3. Clamp the Mounting Support to the base of the Baldwin Tensile machine using three 1/2 –inch diameter bolts through a mating steel channel as shown in Figure 5.
4. Insert eight Release Cables (62678-101) into the Release Cable Block (SK10414).
5. Insert the ball ends of the eight release cables into the roll pins on the release shaft.
6. Install the Pack Release Pill (62751-101) into the release mechanism and safety tie in place.
7. Pull up on the release cable block to remove slack from the eight cables.
8. Ensure cameras and data acquisition are recording.
9. Engage the Baldwin controls to pull up on the release cable block until failure of the release mechanism occurs.
10. Record the peak load value and a description of the failure onto a data sheet.
11. Repeat steps 1 through 9 with one additional new release assembly.

8.1.2 DOWNWARD LOAD

1. Mount a new release assembly (68766-101) onto the trimmed packboard section.
2. Fasten the trimmed packboard section to the Mounting Support (SK10415) using ten #8 fasteners as shown in Figure 7.
3. Clamp the Mounting Support to the base of the Baldwin Tensile machine using three 1/2 –inch diameter bolts through a mating steel channel.
4. Insert eight Release Cables (62678-101) into the Release Cable Block (SK10414).
5. Insert the ball ends of the eight release cables into the roll pins on the release shaft.
6. Install the Pack Release Pill (62751-101) into the release mechanism and safety tie in place.
7. Pull up on the release cable block to remove slack from the eight cables.
8. Ensure cameras and data acquisition are recording.
9. Engage the Baldwin controls to pull up on the release cable block until failure of the release mechanism occurs.
10. Record the peak load value and a description of the failure onto a data sheet.
11. Repeat steps 1 through 9 with one additional new release assembly.

8.2 MODIFIED PIN SHIELD FASTENING TESTING

The purpose of the modified testing is to obtain data regarding the contribution of the pin shields to the force required to cause failure to a release mechanism. Inboard load testing will be performed with pin shields completely removed as an extreme case. Downward load testing will be performed using a pack release assembly that is assembled similar to the state in which the DR1 RH assembly was found upon teardown.

8.2.1 INBOARD LOAD – PIN SHIELDS REMOVED

One test will be performed following the procedure of 8.1.1 with the exception that the FWD and AFT pin shields will be removed prior to Step 8.

8.2.2 DOWNWARD LOAD – MODIFIED PIN SHIELD TESTING

One test will be performed following the procedure of 8.1.2 with the exception that the FWD and AFT pin shields will be modified as described below prior to Step 8.

- Modify one release assembly such that three fasteners are missing in each pin shield as shown in Figure 8, and the remaining fasteners are tightened hand-tight only.

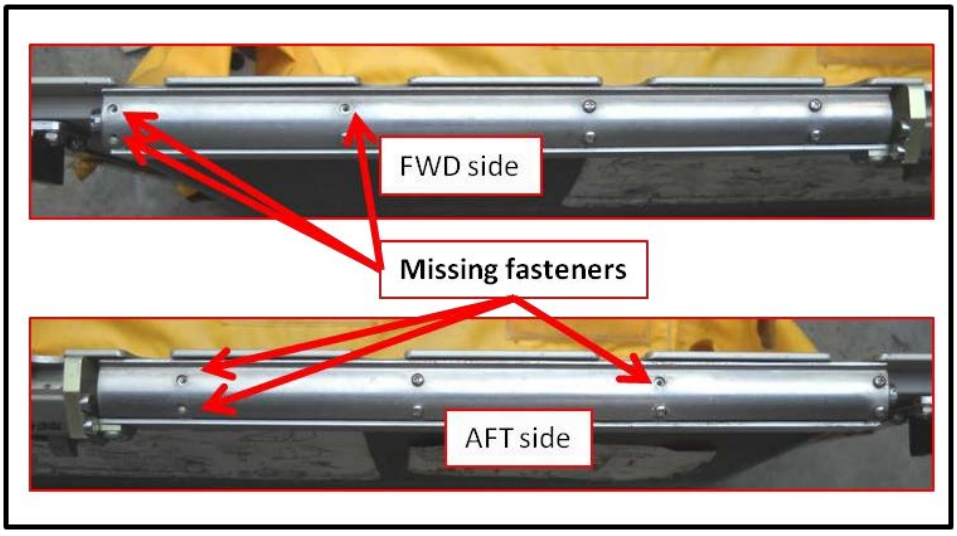


Figure 8. Modified Pin Shield Installation

9.0 CHANGES TO THE TEST PLAN

With the concurrence of the team members, it is permissible to modify the test procedure during conduct of the tests to account for unforeseen circumstances. Any changes to the plan will be detailed in the final test report documenting the results of this testing effort.

AIR CRUISERS
AEROSAFETY & TECHNOLOGY
Emergency Evacuation Systems

ZODIAC AEROSPACE

ENGINEERING DOCUMENT NUMBER 4175

777 Pack Release Tensile Report 11-7-2013

Forced Failure via Tensile Pull

REVISION A
(See Page 2 for Revision Control Sheet)

Prepared by: [redacted]
Robert Hentges
Boeing Program Manager
Air Cruisers' Party Coordinator for DCA13MA120

Distribution: NTSB, FAA, Boeing, Asiana, EVV, MKT, PLA

Q:\EDN\EDN-4175.doc

Revision Control Sheet

REV.	DATE	DESCRIPTION	APPROVAL
A	14 November 2013	Initial Issue	[redacted]

1.0 PURPOSE

The purpose of this report is to document the test results of the tensile tests performed on 777 packboard release mechanisms at Air Cruisers' facility on November 7, 2013.

1.1 TEST PARTICIPANTS

The following people were present for the testing:

Robert Hentges – Air Cruisers. Party Coordinator.
Edward Vienckowski – Air Cruisers. Party Member.
Mike Kret – Air Cruisers. Party Member.
Paul Lacy – Air Cruisers. Party Member.
John Henry – Air Cruisers. Test hardware designer.
Charlie Smith – Air Cruisers. Test support.
Jaime Garay – Air Cruisers. Data acquisition.
Bruce Wallace – Boeing
Sun Ky Oh – Asiana Airlines
Hee Chang Lee – Asiana Airlines
Emily Gibson – NTSB
Peter Wentz - NTSB

2.0 REFERENCE DOCUMENTS

EDN-4105 777 Pack Release Mechanism Strength Test Plan
EDN-4123 777 Pack Release Mechanism Strength Test Report (Test validation)

3.0 BACKGROUND INFORMATION

On July 6, 2013, a Boeing 777-200ER operated by Asiana Airlines as flight 214 crashed in San Francisco, California. The NTSB investigation held at the site of the crash revealed that two of the escape slides (DR1 right & DR 2 right) deployed inside the cabin. The subject systems were sent to Air Cruisers facility in Wall, NJ for further investigation. In addition to DR1 & DR2 RH, the following other items were also sent to NJ for investigation: DR3L, DR4R, DR3R (packboard only), DR4L (packboard & girt bar only).

The investigation revealed a failure mode of the pack release mechanism. The release shafts showed signs of damage in the interface area of the tang. Minor cases showed bulging of the aluminum shaft while more severe cases showed a fracture of the aluminum and significant displacement of the tang. See Figure 1.

4.0 TEST GOALS

The purpose of the testing detailed in this report is to understand the level of force that needs to be applied to the release mechanism to cause the lower lacing cover to release from the mechanism. An additional goal is to replicate the same type of damage seen on the escape slides from the Asiana Flight 214 aircraft, as shown in Figures 1 & 2.

Figure 1. Damage to Release Shaft Door 2 RH.

Figure 2. Damage to Release Shaft Door 1 RH

5.0 TEST RESULTS

Tests were performed according to the approved test plan, EDN-4105, on November 7, 2013. All testing was performed without incident. Additional still images and video files that are not included in this report are kept on file at Air Cruisers and at NTSB. See the 4-Square pages at the end of this report for summary information of each of the six tests performed.

5.1 PEAK FAILURE LOAD SUMMARY

Table 1 shows the summary of the order the tests performed as well as the peak loads measured to release the cables in each test.

Test Order	TEST #	Peak Force (pounds)
1	Inboard Test 1	1639.5
2	Inboard Test 2	1766.5
3	Inboard Test 3 (pin shields removed)	1631.2
4	Download Test 1	1683.2
5	Download Test 2	1781.4
6	Download Test 3 (modified fastening)	1465.8

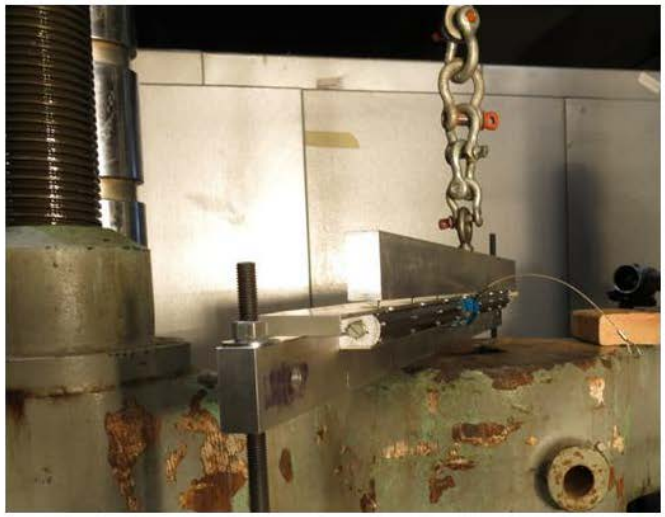
Table 1. Summary of Peak Loads

6.0 Discussion

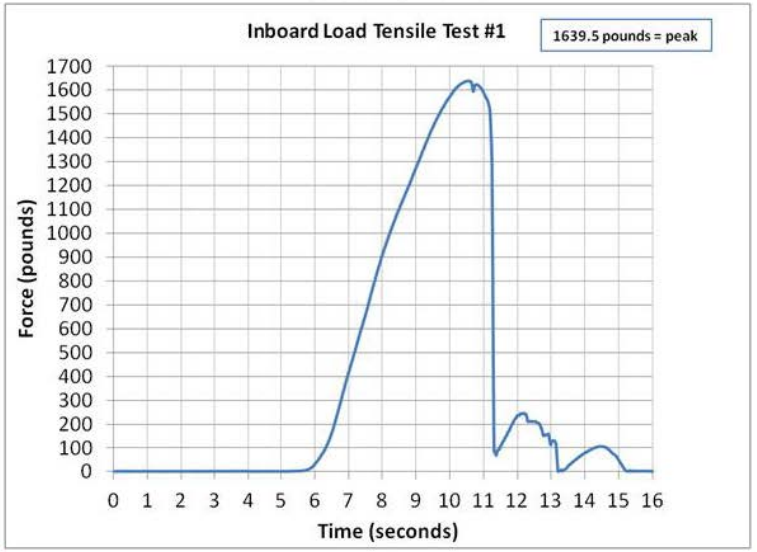
Air Cruisers subjected six release assemblies to ultimate failure loads according to test plan EDN-4105. The peak loads were recorded. The data shows that this test method successfully reproduced the type of damage and final resting position of the roll pins as was seen on some of the release mechanisms from Asiana Flight 214.

Inboard Baseline - Test #1

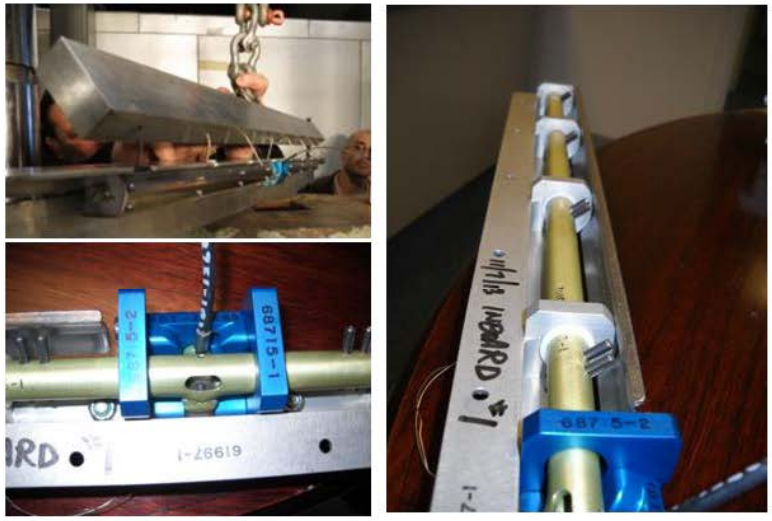
Pre-test Photo



Load Chart



Post-test Photos



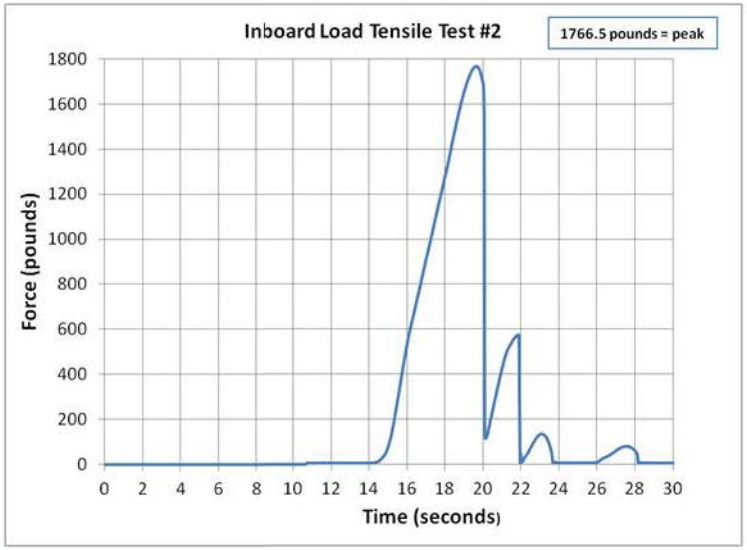
Observations

- Frame rate of 600 fps for video was too high, resulting in dark, out of focus images. Team agreed to reduce to 300 fps for the remaining tests.
- Damage seen in the tang area is consistent with that seen on some of the release mechanisms recovered from Asiana Flight 214.
- Shaft rotated approximately 90°
- 5 cables pulled out nearly simultaneously but the test was ended before any other cables could pull out.

Inboard Baseline - Test #2

Pre-test Photos

Load Chart



Post-test Photos

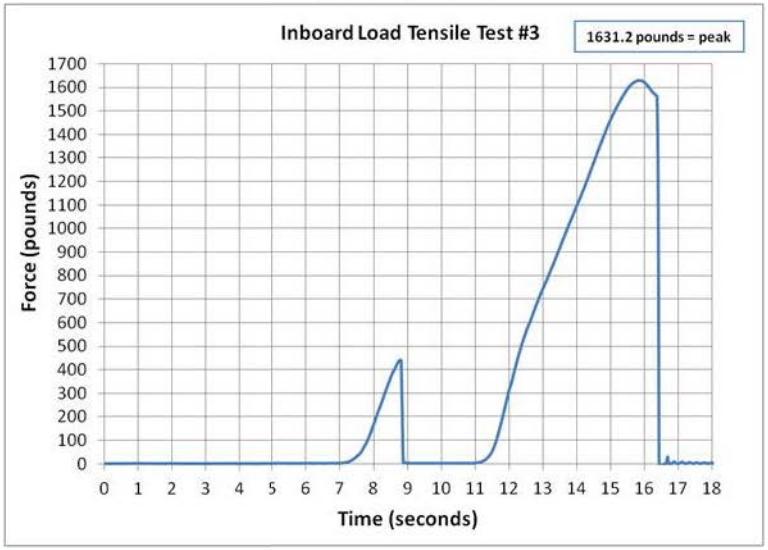
Observations

- Damage seen in the tang area is consistent with that seen on some of the release mechanisms recovered from Asiana Flight 214.
- Red plastic piece was added to the slot on the end of the release shaft as a visual indicator for the rotation.
- Shaft rotated approximately 90°
- Five cables pulled out nearly simultaneously. Two others pulled out as the test continued.

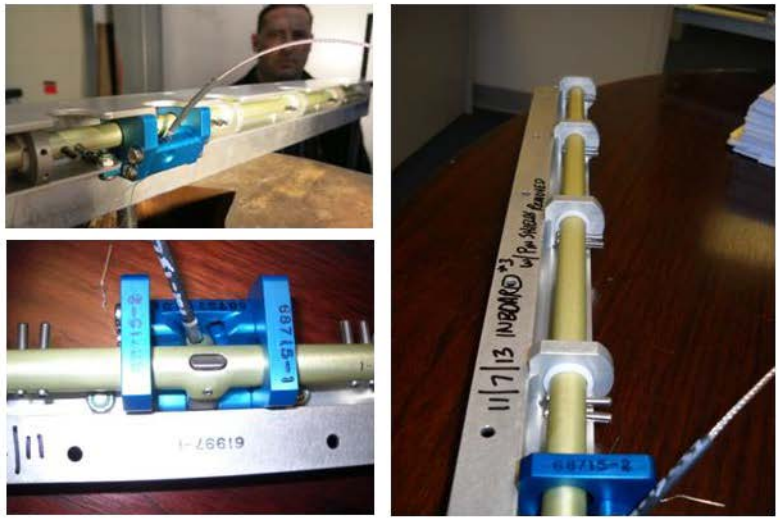
Inboard With Removed Pin Shields - Test #3

Pre-test Photos

Load Chart



Post-test Photos



Observations

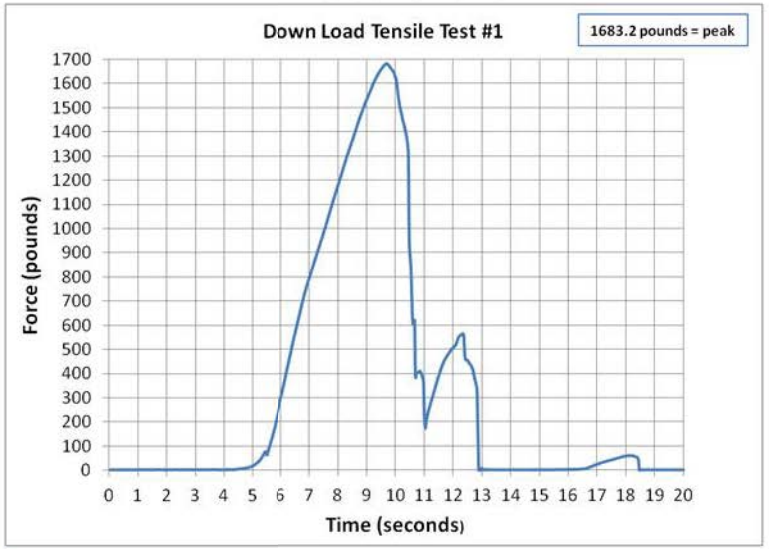
- Damage seen in the tang area is consistent with that seen on some of the release mechanisms recovered from Asiana Flight 214, though the damage is less than that seen on the previous tests that included the pin shields.
- The release shaft did not rotate as far compared to the previous tests that included the pin shields.
- All cables appeared to release simultaneously.

Download Baseline - Test #1

Pre-test Photos




Load Chart



Post-test Photos

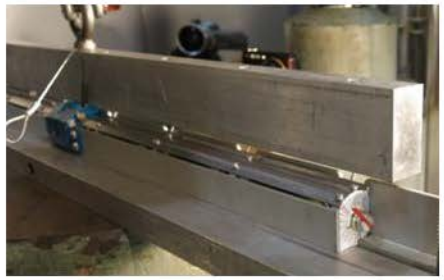



Observations

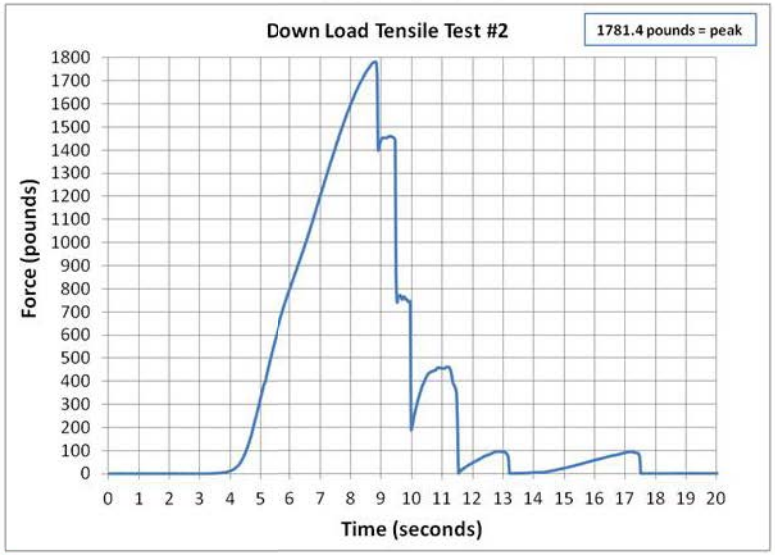
- Damage seen in the tang area is consistent with that seen on some of the release mechanisms recovered from Asiana Flight 214.
- The shaft rotated approximately 90°.
- The cables after the test had a distinct curl to them, which was not observed during the inboard tests.
- 5 cables pulled out simultaneously. Two others pulled out as the test continued.

Download Baseline - Test #2

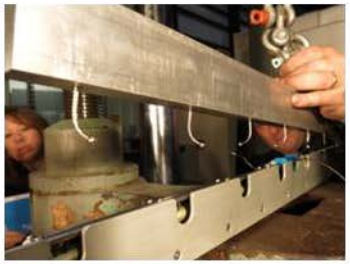
Pre-test Photos



Load Chart



Post-test Photos



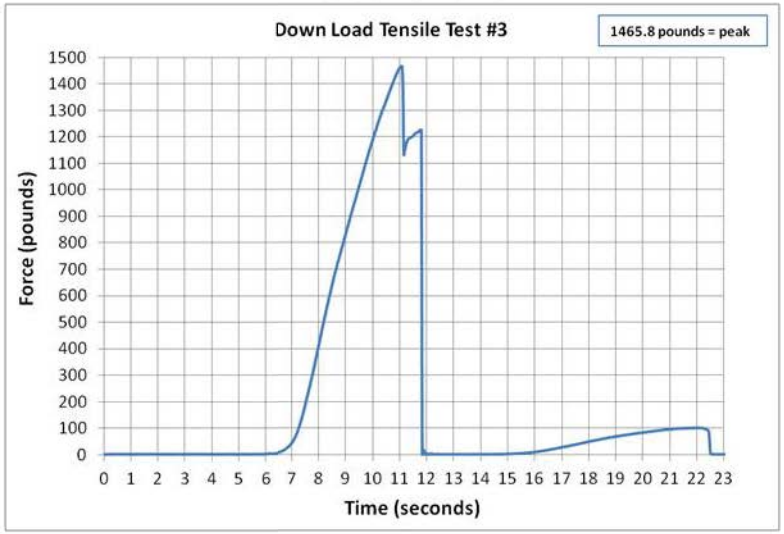
Observations

- Damage seen in the tang area is consistent with that seen on some of the release mechanisms recovered from Asiana Flight 214.
- The shaft rotated slightly less than 90°.
- Four cables release simultaneously. Three others released as the test continued.
- The release cables exhibited a curled appearance.

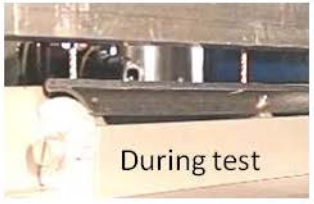
Download With Modified Fastening - Test #3

Pre-test Photo

Load Chart



Post-test Photos



Observations

- Damage seen in the tang area is consistent with that seen on the DR 1RH release mechanism recovered from Asiana Flight 214.
- The shaft rotated much less than 90°.
- This test resulted in the lowest force measured to release the cables.
- The video shows the pin shields flexing, which creates space for the balls to pull through.